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ORIGINAL ARTICLE

Repair of massive ventral hernias with "quilted" mesh

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Abstract

Introduction Prosthetic reinforcement is a critical component of hernia repair. For massive defects, mesh overlap is often limited by the dimensions of commercially available implants. In scenarios where larger mesh prosthetics are required for adequate reinforcement, it may be necessary to join several pieces of mesh together using nonabsorbable suture. Here, we report our outcomes for abdominal wall reconstructions in which "quilted" mesh was utilized for fascial reinforcement.

Methods Patients undergoing open incisional hernia repair utilizing posterior component separation and transversus abdominis muscle release, with use of quilted synthetic mesh placed in the retromuscular position, were reviewed. Main outcome measures included patient, hernia, and operative characteristics and post-operative outcomes, including surgical site occurrence (SSO), surgical site infection (SSI), and recurrence.

Results Thirty-two patients (mean age 55.7 ± 9.3, BMI 38.3 ± 5.8 kg/m^2) underwent open ventral hernia repair with "quilted" mesh placed in the retromuscular position. The mean defect area was 760.1 ± 311.0 cm^2 with a mean width of 24.7 ± 6.4 cm. Quilted meshes consisted of two-piece (69 %), three-piece (19 %) and four-piece (12 %) configurations. Wound morbidity consisted of eight (25 %) SSOs, including four (13 %) SSIs, all of which resolved without mesh excision. With mean follow-up of 9.0 ± 13.6 months, there were two (6.3 %) lateral recurrences, both unassociated with mesh-to-mesh suture line failure.

Conclusions Massive ventral hernias that require giant mesh prosthetics, currently not commercially available, may be successfully repaired using multiple mesh pieces sewn together in a quilt-like fashion. Such retromuscular repairs are durable, without added morbidity due to the mesh-to-mesh suture line. However, additional operative time is required for quilting the mesh together, prompting strong calls for manufacturing of larger mesh prosthetics.

Keywords Quilted mesh · Abdominal wall reconstruction · AWR · TAR · Ventral hernia repair · Incisional hernia · Herniorrhaphy

Introduction

Incisional hernias occur in 10–20 % of patients after abdominal surgery leading to 150,000–250,000 ventral hernia repairs performed each year in the United States alone [1, 2]. Along with restoring the linea alba and medializing the rectus muscles during component separation, mesh prosthetics are regularly used for repairs of massive ventral defects. Though use of mesh in the repair of large ventral hernias is now an almost universally accepted practice, optimal mesh characteristics continue to be a matter of debate. Fortunately, the vast number of commercially available meshes allows surgeons the freedom to select important mesh properties. Type of filament, porosity, and tensile strength can be tailored to particular requisites of

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each hernia defect. This convenience disappears with increasing size of the hernia defect.

In patients with giant ventral hernias, prosthetic reinforcement of the visceral sac with an adequate amount of lateral overlap is a critical component of retrorectus hernia repair [3]. For massive defects, we have found that at least 8–10 cm of overlap beyond the hernia defect is needed to maximize mesh incorporation, provide adequate support, and to minimize recurrence rates [4]. Currently the largest available mesh is 45 cm in width and 30 in length with an area of 1350 cm^2. In our practice, hernias may be as large as 40 cm wide with areas up to 1500 cm^2, creating significant challenges during surgical repair. Unsurprisingly, the dimensions of commercially available meshes prohibit achieving adequate visceral sac reinforcement and/or defect overlap.

In these cases, our practice has been to "quilt" two or more pieces of prosthetic mesh, effectively constructing a larger mesh than currently available. However, the utilization of such mesh constructs has not been investigated well. To our knowledge, there is limited literature regarding the use and safety of quilted mesh to repair large hernias [5]. In this paper, we evaluated the safety and efficacy of quilted mesh use in large retromuscular hernia repairs.

Methods

A prospectively maintained database of abdominal wall reconstructions was used to identify patients who had undergone hernia repair with the use of a "quilted mesh". A quilted mesh was defined as a surgical mesh assembled from two or more commercially available permanent synthetic meshes sutured together.

A total of 32 patients who underwent ventral hernia repair using quilted meshes were identified. Retrospective analysis of the database and medical record was used to record patient demographics, comorbidities, hernia and mesh characteristics, and surgical repair techniques. Demographic data collected included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, number of previous abdominal surgeries, number of previous hernia repairs, previous wound infections, comorbidities, and smoking status. Statistical parameters including mean and variance were calculated.

Primary outcome measures included hernia recurrence rate and surgical site occurrence (SSO). The rate of recurrence was determined using recurrence observed on exam by the primary surgeon, seen on CT scan, or reported by the patient during a follow-up phone call with confirmation on subsequent physical exam or CT scan. The rate of SSOs was determined using the Ventral Hernia Working Group (VHWG) definitions and included surgical site infections (SSIs), seromas, hematomas, wound dehiscence, and enterocutaneous fistulas [6, 7].

Thus far, we most commonly employed quilted mesh in open repairs using the transversus abdominus release (TAR) technique and retromuscular mesh placement [4]. Briefly, our approach involves incision of the posterior rectus sheath with release of the transversus abdominus muscle along its medial edge. Release of this muscle generates access to the space anterior to the transversalis fascia. Lateral dissection to the edge of the psoas muscle provides a sizeable space for sublay mesh placement. Superior extent of the dissection is cephalad to the costal margin and across the retro-sternal space, if necessary. Inferiorly, the space of Retzius is dissected and both Cooper's ligaments are typically identified. The mesh is attached to each of the Cooper's ligaments with a single interrupted absorbable monofilament suture. The rest of the mesh is typically fixated with 4–8 additional transfacial sutures using a suture passer. Subsequently, the anterior rectus sheath is reapproximated to restore the linea alba ventral to the mesh.

Construction of a quilted mesh starts with establishing the desired configuration (Fig. 1). In the case where only two prosthetic meshes are quilted together, the meshes are laid side to side with the long edges abutting (Fig. 2a, b). If a third mesh is needed to cover the defect, it is placed superiorly and at the midline of the initial configuration with the longer side oriented transversely (Fig. 3). For very massive defects, four meshes may be used, in which case they are oriented in a 2 × 2 configuration. Finally, in a very tall patient with a large defect, a five-piece quilt was constructed. The meshes are sutured together using #1 or 0 polypropylene sutures placed approximately 0.5 cm from the edge of each mesh. An initial interrupted suture is placed linking the two corners of the meshes together. A running suture is then placed along the length of the meshes attaching the meshes to each other. This attachment is reinforced with interrupted figure of eight sutures placed approximately 3–4 cm from each other along the length of the adjacent borders. Using two layers of sutures increases durability and strength of the mesh, conceivably preventing herniation at the lines of attachment, if a running stitch were to get compromised. More recently, we have utilized a quilt shaped as a "homeplate" (Fig. 1d) where one 30 × 30 cm prosthetic is placed as a "diamond" in the inferior part of the visceral sac and another 30 × 30 cm mesh is placed as a square in the upper aspect of the visceral sac with an overlap between the two meshes in the mid-portion of the visceral sac. In selective cases where meshes overlap is at least 40 %, we have utilized only limited additional suturing of the two meshes.

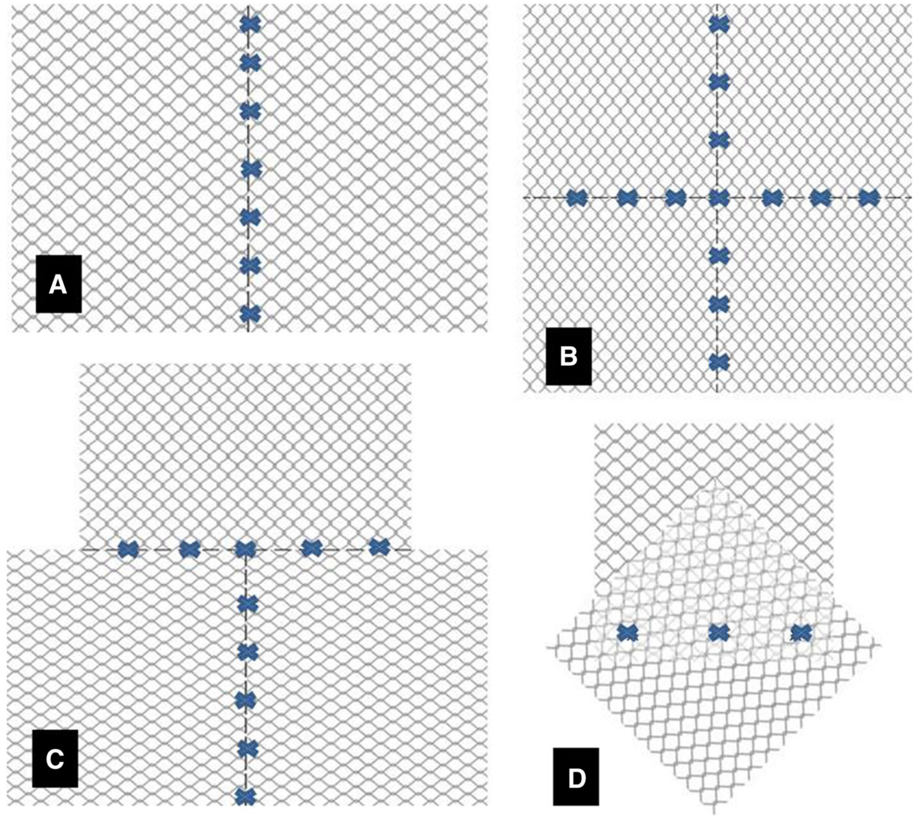

Fig. 1 Various quilting configurations. The meshes are sutured together with a running suture as well as multiple interrupted figure of eight stitches

Results

Thirty-two patients who received quilted mesh as prosthetic reinforcement of their ventral hernia repair were identified and reviewed.

Patient demographics are noted in Table 1. The mean patient age was 55.7 ± 9.3. The patients had a mean BMI of 38.3 ± 5.8 and mean ASA score of 3.0 ± 0.2. The mean number of previous abdominal surgeries was 5.5 ± 3.9 and mean number of previous hernia repairs was 3.7 ± 3.6. Prevalence of comorbidities was 6/32 (25 %) patients with diabetes, 7/32 (21.9 %) with COPD, and 3/32 (0.9 %) had smoked within the past 3 months.

Measurements from pre-operative CT scans found the mean length of hernias operated on to be 30.3 ± 7.6 cm (range 15–52.2 cm) and mean width to be 24.7 ± 6.4 cm (range 15–40 cm). Hernia area ranged from 300 to 1520 cm^2 with a mean of 760.1 ± 311.0 cm^2. Operative characteristics are summarized in Table 1.

Quilted meshes were made from two to four pieces of individual mesh. The majority of quilted meshes, 21/32 (65.4 %), were made from two individual pieces. There were 6/32 (18.8 %) quilted meshes made from three pieces of mesh and 4/32 (12.5 %) made from four pieces and 1 (3.1 %) from five pieces of mesh. In all 32 cases, permanent synthetic polypropylene mesh was utilized. Lightweight mesh was used in 8/32 (25 %) of quilted meshes, mid-weight mesh was used in 6/32 (18.8 %), and heavyweight mesh was used in 18/32 (56.2 %) (Table 2).

Quilted meshes made from lightweight mesh used combinations of two 30 × 30 cm pieces (5/8, 62.5 %) and four 30 × 30 cm pieces (3/8, 37.5 %) for areas of 1800 and 3600 cm^2. Mid-weight quilts were made out of two pieces in 5/6 (83.3 %) cases and four pieces in 1/6 (16.7 %) cases. The two piece mid-weight quilts were made from two 30 × 30 cm meshes (2/6, 33.3 %), two 30 × 45 cm (2/6, 33.3 %) meshes or one 30 × 30 cm mesh and one 15 × 15 cm mesh (1/6, 16.7 %) with areas of 1800, 2700, and 1125 cm^2, respectively. The four piece mid-weight quilt was made from 30 × 30 cm meshes for an area of 3600 cm^2 (1/6, 16.7 %). Finally, the largest prosthetic to date was constructed from five pieces of 30 × 30 cm mid-weight polypropylene mesh for the total size of 4500 cm^2. Heavyweight quilts were made out of two 26 × 36 cm pieces in 12/16 (66.7 %) of cases and three 26 × 36 cm pieces in 6/18 (33.3 %) of cases with areas of 1872 and 2808 cm^2. The average area of a quilted mesh was 2217.7 cm^2 (Table 2).

Complete restoration of the linea alba was achieved in 29/32 (90.5 %) patients. At a mean follow-up of 9 (±14) months, the recurrence rate was 6.3 % (2/32). Surgical site occurrence (SSO) rate was 8/32 (25 %) with one patient

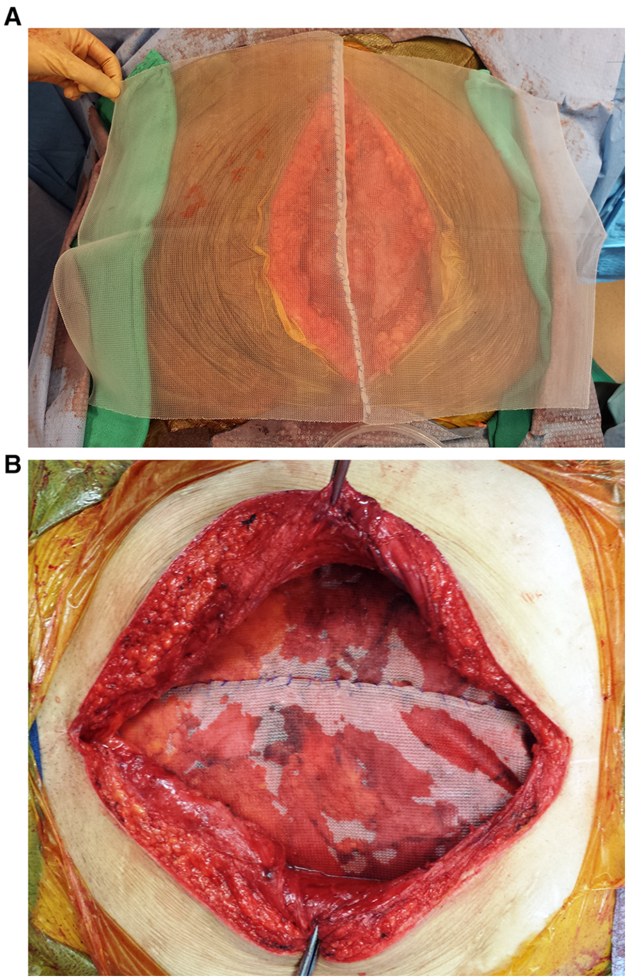

Fig. 2 **a** Quilted mesh constructed from two pieces of prosthetic mesh. **b** Ventral hernia repair with a two-piece quilted mesh

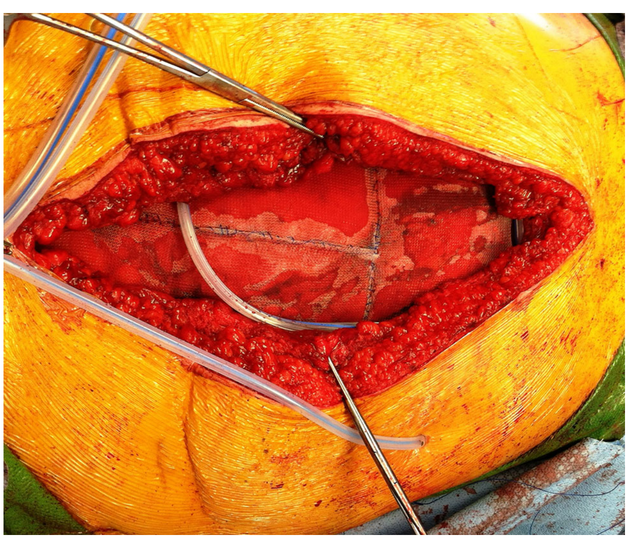

Fig. 3 Ventral hernia repair with a three-piece quilted mesh

having two SSOs. SSOs included surgical site infections (SSIs) (4/32, 12.5 %), wound dehiscences (2/32, 6.3 %), one seroma (1/32, 3.1 %), and one suture abscess (1/32, 3.1 %). The SSIs were both superficial 2/4 (50 %) and deep 2/4 (50 %). Both deep SSIs involved exposed mesh requiring in-office debridement; however, no mesh explantations were necessary (Table 3).

Discussion

The use of quilted mesh is a promising modality for the repair of massive abdominal hernias where commercially available devices are deemed inadequate. At this time, no studies or even case reports exist in the literature documenting the use of quilts for the reinforcement of hernias that exceed the size limitations of commercially available meshes. Our goal was to establish the efficacy, utility, and favorable outcomes of quilted mesh in the repair of massive ventral hernias.

Our study demonstrates that use of quilted mesh in the setting of retromuscular repair results in acceptable recurrence and SSO rates. In our cohort of 32 patients, we had a recurrence rate of 6.3 % and an SSO rate of 25 %. This outcome profile is comparable to that seen in a study by Krpata et al. of 111 patients undergoing retrorectus repair using single pieces of mesh, which cites complications rates of 3.6 and 25.5 % for recurrence and SSO, respectively. Notably, the latter analysis included hernias of all sizes [8]. In a 2014 study that evaluated SSO and recurrence rates based on hernia characteristics including width, "massive" hernias, or those ≥20 cm wide, had recurrence and SSO rates of 34.4 and 41.0 %, respectively (unpublished data). Though we did not perform a side-by-side comparison analysis of massive hernias repaired with and without quilted mesh, the preliminary data may suggest more favorable outcomes when quilted mesh is used.

An important facet of quilted mesh repair is the location of recurrence following quilted repair. Midline recurrences would indicate failure of the quilting process with herniation through the lines of attachment of the individual meshes. The two recurrences seen in our study were both lateral recurrences, consistent with the location of the majority of recurrences in repairs where quilted mesh was not used [9]. While a potential fear of recurrence at the interface between two meshes exists, we have not encountered any failures of the quilted suture line at current follow-up. While our mean follow-up of 9 months may be met with criticism, it is well established that most recurrences take place in the early post-operative period, with studies citing as many as 80 % of recurrences taking place

Table 1 Patient demographics, hernia and wound characteristics

Total patients	32
Age	56 ± 9.3
BMI	38 ± 5.8
Gender, *n* (%)	
Male	18 (56 %)
Women	14 (44 %)
Comorbidities	
Diabetes	6 (19 %)
COPD	7 (22 %)
Smoking within 3 months	3 (9 %)
ASA score	3.0 ± 0.2
Number of prior abdominal surgeries	5.5 ± 3.9
Number of prior hernia repairs	3.7 ± 3.6
Hernia dimensions	
Length	30.3 ± 7.6 cm (15–52 cm)
Width	24.7 ± 6.4 cm (15–40 cm)
Area	760.1 ± 311.0 cm^2 (300–1520 cm^2)
History of prior wound infection	13 (41 %)
Incarcerated (acute and chronic)	29 (91 %)
Wound classification[a]	
Class I/clean	27 (84 %)
Class II/clean-contaminated	4 (13 %)
Class III/contaminated	1 (3 %)
Class IV/dirty	0

Values are listed as mean ± standard deviation (range) or number (percentage)

ASA American society of anesthesiologists, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *DM* diabetes mellitus

[a] Based on CDC guidelines [23]

Table 2 Quilted mesh by components and configuration

Mesh type	Quilt combinations (cm)	Surface area (cm^2)
Lightweight 7 (22 %)	2 × 30 × 30	1800
	4 × 30 × 30	3600
Mid-weight 7 (22 %)	2 × 30 × 30	1800
	2 × 30 × 45	2700
	1 × 30 × 30 + 1 × 15 × 15	1125
	4 × 30 × 30	3600
	5 × 30 × 30	4500
Heavyweight 18 (56 %)	2 × 26 × 36	1872
	3 × 26 × 36	2808

No. of mesh pieces per quilt (*n* = 32)	Frequency
2×	21 (66 %)
3×	6 (19 %)
4×	4 (12 %)
5×	1 (3 %)

Values are listed as number (percentage)

Table 3 Outcomes

Follow-up	9.0 ± 13.6 months
Recurrence	2/32 (6.3 %)
SSO	8/32 (25 %)
SSO by category	
SSI	4/32 (12.5 %)
Superficial	2/32 (6.3 %)
Deep	2/32 (6.3 %)
Wound dehiscence	2/32 (6.3 %)
Seroma	1/32 (3.1 %)
Suture abscess	1/32 (3.1 %)

in the first 2 years post-operatively [10]. The distribution of SSOs also deserves brief mention. Though our SSO rate was remarkable for two instances of mesh exposure associated with deep SSIs, it is important to note that both resolved without the need for complete mesh explantation. One case required minor mesh debridement, wound packing, and antibiotic administration as well as incision and drainage in the other case. Importantly, in both instances the patients had multiply recurrent hernias with many previous surgeries. The outcome profile associated with use of quilted mesh is comparable to that seen in non-quilted cases, and, given the complexity of this cohort of patients, the low recurrence and SSO rates we experienced are promising for this new modality. Furthermore, recurrent hernias did not occur at the suture lines between individual mesh pieces, therefore, we believe that there is adequate durability at the mesh–mesh interface and that quilted mesh is a viable alternative to traditional mesh implants.

An important advantage of using quilted mesh is the freedom it allows in selection of mesh properties. Since the 1950s when using mesh for ventral hernia repair became popularized [11, 12], many groups have described the ideal mesh. In our own practice, we have established intrinsic mesh criteria that we believe are pivotal to the success of ventral hernia repair: biocompatibility, ability to clear infection, as well as pliability and durability in the face of long-term mechanical strain. Additionally, robust reinforcement of the hernia defect requires adequate lateral mesh overlap. Polypropylene is the most common polymer used in surgical devices. Its extreme durability and superior tissue biocompatibility compared to other mesh materials are well proven [13]. Currently, the largest polypropylene mesh on the market is 35.6 cm × 30 cm, which covers a surface area of 1068 cm^2. Because most manufacturers produce meshes no greater than 30–36 cm in width, it can be seen how very large defects are difficult to repair with adequate wide reinforcement of the visceral sac using the standard commercially available implants. Moreover, choosing an ideal mesh requires consideration of additional factors such as porosity, type of filament, and tensile strength. The current paucity of large meshes limits a surgeon's ability to select for these mesh qualities. Using a quilted mesh not only overcomes the limitations of size, but also allows mesh properties to be chosen based on what best suits the needs of the patient and hernia.

In recent years, numerous studies have found that a significant factor in recurrence rates and overall durability of a hernia repair is the amount of lateral mesh overlap [14]. Hernia recurrence typically occurs at the interface between the mesh and the abdominal tissue [15] with wide lateral overlap shifting this interface to an area not overlying the hernia sac. Large overlap also improves mesh ingrowth and integration into the abdominal wall resulting in a smaller foreign body response and decreased incidence of rejection. Furthermore, a smaller degree of mesh contraction is seen post-operatively [16]. An overlap of at least 5 cm in all directions is advised, with some studies citing a minimum overlap of up to 7–8 cm in all directions [17, 18]. The Rives–Stoppa technique, while considered the gold standard for hernia repair, does not allow for this type of large mesh overlap due to the lateral border of the posterior rectus sheath [19]. This presents a problem with patients who have defects larger than 15 cm [20]. In our practice, we often employ the transversus abdominis release (TAR) approach for large ventral hernias. By releasing the transversus abdominis muscle, we gain access to the space anterior to the transversalis fascia, allowing for large mesh placement in a well-vascularized bed, as well as allowing for significant medial mobilization of the posterior rectus sheath. This dissection plane is contiguous with the retromuscular space and given a large defect, has the potential to be extended considerably in all directions: superiorly to the costal margins, laterally to the psoas muscles, and inferiorly toward the space of retzius [4]. By creating this large space for sublay mesh placement, the TAR technique ensures room for adequate overlap in even the largest of hernia defects. However, at this stage a primary limitation becomes the size of the mesh available. Though some commercially available devices may be sufficiently large enough to cover the hernia defect, they lack the additional width and surface area needed to create a wide lateral overlap and reinforcement of the visceral sac. Furthermore, the risk of mesh shrinkage, which ranges from 28–33 % depending on weight of the mesh [21], must also be considered. By quilting together mesh pieces we were able to create implants up to 60 cm in width, with surface areas up to 4500 cm^2. The quilting process significantly expands the number of hernias that can be repaired without sacrificing lateral overlap.

The definitions of mesh weight are not universally clear. We consider a mesh lighter that 40 g/m^2 to be "lightweight", 40–80 g/m^2 to be mid-weight, and over >80 g/m^2 to be heavyweight. The choice of mesh weight remains debatable. For the vast majority of our patients, we utilize a mid-weight polypropylene mesh. For those patients, where midline cannot be approximated ventral to the mesh without significant tension, when significant deficits of anterior fascia exist due to previous resections/debridements, previous mesh removal as well as in patients with flank/subcostal defects, a traditional heavyweight polypropylene mesh is typically used.

In addition to the sutures needed to secure the mesh to the abdominal wall, the quilted mesh technique involves additional suture at the mesh–mesh interface. With the increased amount of suture material being placed, suture abscesses are a valid concern. These abscesses and their association with chronically draining sinuses are not uncommon, particularly after the acute resolution of a surgical site infection. Theoretically, the presence of more suture material to sew the mesh together would increase the likelihood of a patient developing this smoldering wound morbidity [22]. To obviate this complication, we place the stitches facing the posterior rectus fascia, rather than anteriorly—a subtle, yet important technical point. Our sole occurrence of a suture abscess speaks to the success of this approach.

Though quilted mesh offers an inventive and durable approach to reinforcement of massive abdominal wall defects, it is not without drawbacks. The quilting process is a time-intensive process that increases the length of the procedure and time under anesthesia by approximately 20–45 min depending on the number of mesh pieces joined together, while also increasing cost of mesh and suture. While quilted mesh represents a resourceful solution to procuring an adequately sized mesh, ultimately, it is critical that manufacturers evolve their mesh products to fit the needs of these large defects. Manufacturer-produced extra large synthetic meshes would obviate the need for intraoperative fabrication of appropriately sized prosthesis and allow for optimal repair of large or complex ventral hernias.

Conclusion

Quilted mesh provides an innovative and practical approach to the repair of massive hernias that would have previously been considered inoperable. The technique of quilting individual mesh pieces together eliminates the size constraints imposed by dimensions of currently manufactured meshes, allows for adequate lateral overlap with wide reinforcement of the visceral sac, and preserves the surgeon's ability to select mesh properties best suited to the patient and hernia. Given the favorable outcome profile, as well as absence of recurrences associated with the quilted suture line, we have shown that quilted mesh is a durable and safe option. However, given the extra burden and costs of producing quilted reinforcements during the time of operation, production of large synthetic prosthetic meshes is essential to further optimize repairs of large and complex ventral hernias.

Conflict of interest NP declares no conflict of interest. SY declares no conflict of interest. AM declares no conflict of interest. SO declares conflict of interest—paid consultant for CR Bard. AP declares conflict of interest—paid consultant for CR Bard. YN declares conflict of interest—paid consultant for LifeCell, CR Bard and Cooper Surgical.

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